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(54) Title: BASE STATION SYSTEM ARCHITECTURE

(57) Abstract: A packet-switched Base Station System (200) transmission infrastructure is disclosed, whereby statistical multiplexing can be used to improve the utilization of installed transmission resources. In such a packet-based network, all types of traffic (e.g., signalling, speech, Circuit-Switched Data and GPRS traffic) can be mixed because efficient mechanisms are made available for assuring that Quality of Service requirements are met. As such, the mixing of speech and data traffic with their different Quality of Service requirements is made especially efficient by the infrastructure (200) disclosed. Notably, the infrastructure (200) disclosed can be implemented for any Internet Protocol-(IP-)based Random Access Network (RAN), and in particular (but not exclusively), can be implemented for TDMA and Code Division Multiple Access (CDMA) systems.

BASE STATION SYSTEM ARCHITECTURE

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates in general to the mobile communications and Internet fields and, in particular, to an Internet Protocol (IP)-based Base Station System (BSS) architecture.

Description of the Prior Art

FIGURE 1 is a block diagram of an existing Global System for Mobile Communications (GSM) system model. Referring to FIGURE 1, the GSM model (10) shown includes a Radio Access Network (RAN) known as a BSS (12). The BSS includes two types of logical nodes: a Base Transceiver Station (BTS) 14; and a Base Station Controller (BSC) 16. In order to support circuit-switched speech or data services, the BSC 16 inter-operates or interworks ("interworking" is a term of art) with a Mobile Switching Center (MSC) 18 via an open (non-proprietary) interface known as an A-interface. In order to support packet-switched data services (e.g., the General Packet Radio Service (GPRS) in the GSM), the BSC 16 interworks with a Serving GPRS Support Node (SGSN) 20 via a second open interface known as a Gb interface. As such, an MSC (e.g., 18) or SGSN (e.g., 20) can serve one or more BSCs.

Each BSC in a GSM network can control a plurality (typically hundreds) of radio cells. In other words, each BSC (e.g., 16) interworks with a plurality (hundreds) of BTSs via respective Abis interfaces. Each BTS (e.g., 14) is responsible for the transmission and reception of radio signals over an air interface, Um, in one cell. Consequently, the number of cells in a GSM BSS is equal to the number of BTSs in that BSS. As such, the BTSs are geographically distributed to provide adequate radio coverage of a BSC area, which forms part of a GSM Public Land Mobile Network (PLMN).

Additionally, the BTSs provide the capacity to carry a plurality of connections (calls) between Mobile Stations (MSs) (e.g., 22) and respective BSCs. In the GSM, each BTS is equipped with one or more Transceivers (TRXs). Each such TRX (not shown) is capable of handling eight timeslots of a Time Division Multiple Access (TDMA) frame. Furthermore, each such timeslot can be assigned different combinations of logical channels, such as, for example, Broadcast Control Channels (BCCHs) and Common Control Channels (CCCHs), Stand-alone Dedicated Control Channels (SDCCHs), and Traffic Channels (TCHs). A TCH can be either a Full-rate TCH (TCH/F) or Half-rate TCH (TCH/H). Each timeslot can support either one TCH/F or two TCH/Hs (simultaneously).

FIGURE 2 is a block diagram of a specific implementation of a GSM BSS, which has been developed and manufactured by Ericsson. The BSS (120) shown includes a BSC 160, which is a physical node used to implement the logical node 16 (FIG. 1) of the model system. The BSC 160 functionality is based on a proprietary Ericsson digital switch technology known as an AXE Digital Switching System. Essential parts of the BSC 160 are a Central Processor (CP) 162 and Group Switch (GS) 164.

The Radio Base Stations (RBSs) 140a-n shown are physical nodes which are used to implement the BTSs 142a-n (cells). The RBSs are typically located at sites nearby the BTS's antennas. As such, two different RBS configurations are exemplified by the RBSs shown in FIGURE 2. For example, the RBS 140a includes three BTSs (e.g., 142a-c) which correspond to a sector site with each antenna covering 120 degrees. The RBS 140n includes one BTS (142n) which corresponds to an omni-site with a single omni-directional antenna.

A Transcoder Controller (TRC) 170 includes a pool of Transcoder/Rate Adaptors (TRAs) 176a-n. The TRC 170 functionality is also based on the AXE digital switching technology, and thereby includes a CP 172 and GS 174. As such, each TRA 176a-n includes, for example, a GSM speech coder/decoder (codec), which transcodes Pulse Code Modulated (PCM) coded speech from 64 kbps on the MSC (18) side to 13 kbps (e.g., for full-rate GSM speech) on the BTS (142) side. Preferably, the TRAs are located as close to the A-interface as possible, in order to save transmission costs in the BSS transmission network.

For the BSS shown in FIGURE 2, the A-interface is split into two parts. One part of the A-interface (190a) carries the Signalling System Number 7 (SS7) signalling information that terminates in the BSC 160. The second part of the A-interface (190b) carries the payload information that terminates in the TRC 170. For example, the signalling and payload information are carried in different 64 kbps timeslots. An Ericsson proprietary Ater interface is arranged between the BSC 160 and TRC 170. The Ater interface is used, for example, when the BSC requests an allocation of TRA devices and for connections to be setup. Notably, a different Ericsson implementation (not shown) integrates a BSC and TRC into one physical node.

FIGURE 3 is a block diagram that illustrates how MS connections can be setup with the GSM BSS implementation shown in FIGURE 2. FIGURE 3 shows signalling connections (dashed lines) and payload connections (solid lines) both before and after a handover procedure. The MS (e.g., 22) signalling connection is controlled by the BSC CP 162, which controls, for example, channel activation in a BTS. Signalling messages between the MSC 18 and the MS 22 are routed via the BSC 160 and the BTS that creates the serving cell. Also, a signalling connection is made between the BSC CP 162 and the TRC CP 172.

The CPs 162, 172 also control the setup of payload connections via the respective GS 164, 174. As such, the MSC 18 requests an assignment of a traffic channel via the A-interface. The BSC 160 then requests the TRC 170 to allocate resources for the connection. The TRC then allocates a free TRA (176a-n) for the connection, and a 64 kbps path is setup via the GS 174 to a 64 kbps circuit at the selected A-interface, for example, by the MSC 18. On the other side, a free 16 kbps circuit is selected (for full-rate speech) for a path towards the BSC 160. Next, the BSC 160 sets up a 16 kbps path via its GS 164 to the allocated timeslot resource in the BTS (142a-n). Notably, the BTS multiplexes the signalling and payload signals in the same air interface timeslot.

A major function of the BSC 160 is to control handovers. At the onset of a handover, a new BTS is selected by the BSC, such as, for example, a BTS in a different RBS. Next, the BSC allocates and activates a channel in the new BTS, and then commands the MS (22) to switch to this channel. Actually, an additional TRA (176a-

n) is allocated at the onset of the handover, and a path for the payload connection is setup to the new BTS 142n via the GS 174 in the TRC 170 and GS 164 in the BSC 160. At handover, the connection is switched between the TRAs on the 64 kbps side. The old TRA with its connections is then released.

Description of the Problems

The main problem with the prior art BSS solutions is that the BSS infrastructures are circuit-switched and connection-oriented. A significant drawback of such an infrastructure is that the transmission efficiency is relatively low, and the connection switching arrangement is relatively complex. Another drawback of such an infrastructure is that both the BSC and TRC must handle both the signalling and payload and thus each cannot be specialized.

Another drawback of the existing BSS infrastructures is that although full duplex 16 kbps pipes are setup for each call, normally one person on a call is quiet while the other person is speaking. Consequently, at the radio air interface, a Discontinuous Transmission (DTX) mode can be applied, which means that the transmission is controlled (switched on and off) depending on the amount of voice activity. The purpose of the DTX mode is to reduce the interference over the air. However, this advantageous DTX mode is not utilized in the existing BSS infrastructures.

Another problem with the existing BSS infrastructures is related to the peak allocation of transmission bandwidth, which is an even more significant problem for data calls. Typically, data applications are "bursty". During file transfers, a relatively high bandwidth is needed (preferably a multi-slot connection) for a short duration while the data is being downloaded. However, for most of the time during such a session, no data is transferred. As such, the GPRS has been standardized and offered as an alternative to Circuit-Switched Data (CSD). The GPRS is a packet-based service, wherein spectral efficiency is achieved by statistical multiplexing in the air interface. This approach allows an operator to charge only for transferred data and not for the time that a user was logged in. Nevertheless, in the existing BSS infrastructures, the GPRS transmission infrastructure is also circuit-switched.

An Adaptive Multi-Rate (AMR) protocol has been standardized for speech services. In accordance with the AMR protocol, the coding is changed dynamically during a call. These changes depend on the interference circumstances in the air interface (e.g., between full-rate and half-rate connections). Consequently, the transmission bandwidth requirements can vary significantly during a call.

In the existing BSS infrastructures, the bandwidth is peak allocated on the Abis interface for the signalling and payload. The traffic is concentrated in the physical BSC, and less bandwidth is allocated on the A-interface (trunking gain). Consequently, relatively small BSCs should be distributed nearby the RBS sites in order to save transmission costs. However, there are still significant problems with such a solution, such as, for example, relatively high site costs and Operation and Maintenance (O&M) costs, and more frequent inter-BSC handovers.

Other existing solutions include distributed switches which are controlled from a centrally-located BSC. In order to cope with the varying requirements for bandwidth, switching on demand can be applied. However, this approach adds a great deal of complexity and increases the signalling in the network. Nevertheless, these existing solutions are also inefficient because of delays in the network. In any event, as described in detail below, the present invention successfully resolves the above-described problems and other related problems.

SUMMARY OF THE INVENTION

In accordance with the present invention, a packet-switched BSS transmission infrastructure is provided, whereby statistical multiplexing can be used to improve the utilization of installed transmission resources. In such a packet-based network, all types of traffic (e.g., signalling, speech, CSD and GPRS traffic) can be mixed because efficient mechanisms are made available for assuring that Quality of Service (QoS) requirements are met. As such, the mixing of speech and data traffic with their different QoS requirements is made especially efficient. More specifically, in accordance with a preferred embodiment of the present invention, a BSS infrastructure is provided which is based on an IP or packet-based, connection-less protocol. Also, certain mechanisms are provided (e.g., Differentiated Services) for assuring that the

QoS requirements are met, and a relatively high transmission efficiency for short packets (e.g., header compression) is also assured. Notably, the present invention can be implemented for any IP-based Random Access Network, and in particular (but not exclusively), can be implemented for TDMA and Code Division Multiple Access (CDMA) systems.

An important technical advantage of the present invention is that a BSS architecture is provided whereby the infrastructure is packet-switched with a connection-less orientation.

Another important technical advantage of the present invention is that a BSS architecture is provided whereby all types of traffic can be mixed.

Still another important technical advantage of the present invention is that a BSS architecture is provided whereby the mixing of speech and data traffic is particularly efficient.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a block diagram of an existing GSM system model;

FIGURE 2 is a block diagram of a specific implementation of a GSM BSS;

FIGURE 3 is a block diagram that illustrates how MS connections can be setup with the GSM BSS implementation shown in FIGURE 2;

FIGURE 4 is a block diagram of an IP-based BSS that can be used to implement the preferred embodiment of the present invention;

FIGURE 5 is a block diagram of the IP-based BSS shown in FIGURE 4 but with greater detail than FIGURE 4;

FIGURE 6 is a block diagram that illustrates how MS signalling connections can be setup, in accordance with the preferred embodiment of the present invention;

FIGURE 7 is a sequence diagram that illustrates a method that can be used to setup MS signalling connections, such as, for example, the connections shown in FIGURE 6;

FIGURE 8 is a block diagram that illustrates how a traffic channel can be initially assigned, in accordance with the preferred embodiment of the present invention;

FIGURE 9 is a sequence diagram that illustrates a (normal sequence) method that can be used to initially assign traffic channels, such as, for example, the traffic channel(s) described with respect to FIGURE 8;

FIGURE 10 is a block diagram that illustrates how an inter-cell handover can be performed, in accordance with the preferred embodiment of the present invention; and

FIGURE 11 is a sequence diagram that illustrates a (normal sequence) method that can be used for performing inter-cell handovers, such as, for example, the handover(s) described with respect to FIGURE 10.

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention and its advantages are best understood by referring to FIGUREs 1-11 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

Essentially, in accordance with the present invention, a packet-switched BSS transmission infrastructure is provided, whereby statistical multiplexing can be used to improve the utilization of installed transmission resources. In such a packet-based network, all types of traffic (e.g., signalling, speech, CSD and GPRS traffic) can be mixed because efficient mechanisms are made available for assuring that Quality of Service (QoS) requirements are met. As such, the mixing of speech and data traffic with their different QoS requirements is made especially efficient.

More specifically, in accordance with a preferred embodiment of the present invention, a BSS infrastructure is provided which is based on an IP- or packet-based, connection-less protocol. Also, certain mechanisms are provided (e.g., Differentiated Services) for assuring that QoS requirements are met, and a relatively high transmission efficiency for short packets (e.g., using header compression) is also assured. Notably, the present invention can be implemented for any IP-based Random Access Network, and in particular (but not exclusively), can be implemented for TDMA and CDMA systems.

Specifically, FIGURE 4 is a block diagram of an IP-based BSS 200 that can be used to implement the preferred embodiment of the present invention. For this exemplary embodiment, the IP-based BSS 200 includes three types of nodes connected to an IP network 208. A first node connected to the IP network 208 is an RBS 202. In general, the RBS 202 corresponds to the RBSs shown in FIGUREs 2 and 3. However, for this embodiment, the RBS 202 also provides IP support for the BSS 200. For example, the RBS 202 functions as an IP host and includes an IP router (not shown). The IP router can be used to route payload User Datagram Protocol (UDP) datagrams to one or more TRXs and also for connecting a plurality of RBSs in various topologies.

A second node connected to the IP network 208 is a GateWay (GW) 204. The GW 204 can be used to terminate the A-interface. Also, the GW 204 can perform a conversion from one protocol (e.g., SS7 protocol) to another protocol (e.g., Transmission Control Protocol (TCP)/IP). The GW 204 also includes a Media GW (MGW) which corresponds to a TRC shown in FIGUREs 2 and 3. The MGW (not shown) includes a pool of TRA devices (not shown), which, when allocated, are connected to the A-interface in a manner which is similar to that of the TRAs shown in FIGUREs 2 and 3. However, the IP network (e.g., GSM) side of the TRAs in the MGW are connected to respective UDP ports. For this embodiment, the GW 204 is preferably connected to the IP network 208 via a separate router (not shown).

A third node connected to the IP network 208 is a Radio Network Server (RNS) 206. The RNS 206 corresponds to a BSC shown in FIGUREs 2 and 3. A primary difference between the RNS 206 and a BSC is that the RNS does not switch payloads and does not include a GS. As such, for this embodiment, the RNS 206 carries signalling only, and includes a pool of processors (e.g., the number of processors determined by capacity requirements). The RNS 206 provides a robust, general purpose distributed processing environment, which can be based on a standard operating system such as, for example, Solaris®. The RNS 206 can serve one or more logical BSCs and is preferably connected to the IP network 208 via a separate router.

As shown in FIGURE 4, the payload is routed directly between the GW 204 and RBS 202, without passing through the RNS' 206 processors. The A-interface signalling is routed between the RNS 206 and GW 204, and the Abis interface signalling is routed between the RNS 206 and the RBS 202. A modified Ater interface (not shown) is provided between the RNS 206 and the GW 204.

As described above, certain routers can be located at the physical nodes shown in FIGURE 4 and respectively connected to the IP network 208. Also, other routers can be located at hub sites. The routers function as concentrators for payload and signalling and thereby provide trunking gain. As such, the application software running in the respective nodes needs no information about the transmission infrastructure, and only the addresses of the signalling and payload endpoints are known. Consequently, the transmission infrastructure can be efficiently used with relatively low complexity. Also, in addition to the transmission efficiency gained by the IP-based BSS shown in FIGURE 4, the separation of the payload and signalling information provides a technology-based separation of the RNS and GW functionality. As such, the RNS 206 can handle relatively high-level traffic control functions, advanced radio network algorithms, and network administration functions, while the GW 204 can handle relatively low-level, real-time media stream conversions.

FIGURE 5 is a block diagram of the IP-based BSS 200 but with greater detail than shown in FIGURE 4 (for circuit-switched services). Referring to FIGURE 5, note that all IP-based BSS internal signalling is performed in accordance with the IP. Also, note that the RNS 206 can interwork with the GW 204 via different interfaces corresponding to different logical nodes in the GW. Alternatively, for a different embodiment, the MGW 205 and SS7 GW 207 can be implemented in separate physical nodes.

The SS7 GW 207 functions to perform a protocol conversion between the SS7 protocol on the A interface and the TCP/IP. The SS7 GW 207 also functions to relay the Base Station System Application Part (BSSAP) signalling messages between the MSC 218 and the RNS 206. The RNS 206 controls the setup and release of connections with the MS 222.

The MGW 205 functions to perform transcoding of CS speech and rate adaption of CS data. At the A-interface with the MGW, speech PCM samples are transmitted in 64 kbps circuits. On the other (IP) side of the MGW 205, the CS (e.g., GSM) coded speech frames are carried in UDP packets over the IP. The MGW includes a pool of TRA devices (each device capable of performing speech transcoding and data rate adaption), and a resource manager which, on request from the RNS 206, allocates appropriate resources and sets up or switches appropriate connections. For this embodiment, the RNS 206 controls the MGW 205 in accordance with the known BSC/TRC Application Part (BTAP) protocol. Alternatively, the RNS can control the MGW in accordance with the protocol based on the known H.248 protocol.

The RBS 202 includes a plurality of TRXs (not shown). Each such TRX can be connected to one or more antenna systems via appropriate combiners and distributors. A CS TRX can carry a TDMA frame, which (e.g., for the GSM) is composed of eight air interface timeslots. Each TRX performs such air interface functions as physical channel scheduling, channel coding and interleaving, ciphering, modulation, equalization and detection, and radio transmission and reception (including frequency hopping). A modified Abis Radio Signalling Link (RSL) interface is used for traffic signalling between the RNS 206 and the RBS 202. For this embodiment, the RSL interface functions to control channel activation and release, and handles the LAPDm link, etc. The RSL is also used to convey messages to and from the MS 222.

The RNS 206 functions to setup and release connections between an MS (e.g., 222) and the MSC 218, coordinate the assignment of traffic channels, and control the performance of handovers. The RNS also functions to distribute paging messages to cells belonging to, for example, a particular Location Area (LA) or BSC area. Furthermore, the RNS functions to handle a number of Radio Network algorithms, such as, for example, Channel Allocation algorithms for selecting air interface channels, Locating algorithms for selecting cells in the active mode, and MS and BS Power Control algorithms. Notably, for certain configurations, parts of these functions can be distributed to the RBS 202. In order to support High Speed CSD (HSCSD), the RNS functions to allocate a multi-slot channel which comprises a plurality of consecutive timeslots. These timeslots are handled independently in the RBS 202. The

MGW 205 functions to multiplex the timeslot channels, and rate adapts the multiplexed channel to 64 kbps at the A-interface.

For this embodiment of an IP-based BSS, the communication between physical nodes (e.g., RBS, RNS, GW) is performed in accordance with the IP. As such, each node includes one or more hosts to terminate the IP. For example, IP hosts that can be included in these nodes are transceiver units and one or more common processors in the RBS 202, transcoder boards and one or more common processors in the GW 204, and processors in the RNS 206.

The TCP/IP is preferably used as a reliable transport medium for all signalling. For example, one or more TCP connections that serve RSLs can be setup semi-statically when the RBS 202 (or parts of the RBS) registers with the RNS 206. Also, semi-static TCP connections can be setup between the RNS 206 and the SS7 GW 207 respective to the MGW 205 to function as so-called "Connection-Less Signalling" (e.g., signalling not related to any particular MS connection). Certain additional TCP connections can also be setup dynamically between the RNS 206 and the respective GW employed for each MS connection (e.g., Connection-Oriented Signalling). Furthermore, certain advanced algorithms can be used to adapt the number of TCP connections to the traffic load. As such, different TCP port numbers can be used for identifying the TCP connections which are using the same IP address.

For this exemplary embodiment, UDP packets can be used for transporting the payload, in order to meet QoS requirements with relatively short delays. The reliability of the UDP transport is relatively low because the UDP data are typically not re-transmitted and lost packets are discarded. However, the use of a UDP transport can be acceptable for speech information if the frequency of lost frames is not too high.

In the BTSs (e.g., associated with the RBS 202), each individual traffic channel can be assigned its own UDP port number. For example, for each timeslot, one UDP port number can be assigned to the TCH/F, and one UDP port number can be assigned to each TCH/H (i.e., three UDP ports per timeslot, or 24 UDP ports per TRX). For those cases where a TRX is an IP host, the set of UDP port numbers can be repeated for each such TRX.

A similar arrangement can be used in the MGW 205. For example, each TRA device in the MGW 205 can be assigned a fixed UDP port number (or two UDP port numbers when a TRA communicates with two TCHs, such as for example, during a handover). Alternatively, a UDP port number can be allocated dynamically to a TRA device when that TRA device is allocated for use. In general, the assigned or allocated UDP port numbers will become known after a TRA device or TCH is allocated. The TRA UDP port number is sent to the TCH, and vice versa, when a traffic connection is setup.

FIGURE 6 is a block diagram that illustrates how MS signalling connections can be setup, in accordance with the preferred embodiment of the present invention. FIGURE 7 is a sequence diagram that illustrates a method that can be used to setup MS signalling connections, such as, for example, the connections shown in FIGURE 6.

Referring to FIGUREs 6 and 7, in general for this embodiment, an MS connection is setup via an SS7 GW (e.g., 207). As such, signalling connections or routing are denoted by the dashed lines shown in FIGURE 6. Specifically, following the exemplary method 300 shown in FIGURE 7, at step 302, an MS (e.g., 222) initiates a signalling connection setup sequence by transmitting a Channel Request (access burst), which is received and detected by a BTS (associated with the RBS 202). In response, the RBS 202 measures the access delay for the received burst, and at step 304, sends a Channel Required message (transported via the IP network 208) to the RNS 206. When the Channel Required message is received, at step 306, the RNS 206 allocates a dedicated channel (e.g., SDCCH) and sends a Channel Activation message to the RBS 202 (via the IP network) for the selected channel. Responsive to the received Channel Activation message, at step 308, the RBS sends (via the IP network) a Channel Activation Acknowledgment message to the RNS 206. Upon receipt of the Acknowledgment message, at step 310, the RNS 206 sends (via the IP network) an Immediate Assignment Command message (including an Immediate Assign message) to the RBS. At step 312, the RBS 202 transmits the Immediate Assign message to the MS 222 on the CCCH downlink.

The Immediate Assign message received by the MS includes a description of the new channel to be assigned, and a Timing Advance (TA) order. In response to the received Immediate Assign message, the MS 222 switches to the assigned channel and uses the information from the TA order to advance the transmission of the Normal Burst so that it occurs within the transmission timeslot. At step 314, the MS initiates the establishment of a Link by transmitting an Initial Message over the air interface on an LAPDm Set Asynchronous Balanced Mode (SABM) frame. Responsive to the received Initial Message, at step 316, the RBS 202 sends (via the IP network 208) the Establish Indication from the Initial Message to the RNS 206. Also in response to the received Initial Message (from step 312), the RBS 202 transmits an Unnumbered Acknowledgment (UA) message on an air interface downlink frame to the MS, which in turn, establishes the radio link.

The establishment of the initial link is a special function. For example, as described above, the SABM frame carries an Initial MS message which is forwarded to the RNS 206 in the Establish Indication message. The Initial MS message is also sent back to the MS in the UA frame for contention resolution. As such, the Initial MS message functions as a network service request (e.g., Location Updating Request, IMSI Detach Indication, or CM Service Request). The Initial MS message can also function as a Paging Response.

Upon receiving an Establish Indication message (e.g., from step 316), the RNS 206 initiates the setup of a connection towards the MSC 218. For example, at step 320, the RNS sends a Connection Request message (including the Initial MS message from step 316) to the SS7 GW 207 via the IP network 208. In response to the receipt of the Connection Request message, at step 322, the SS7 GW 207 sends a Connection Request message (including the Initial MS message) to the MSC 218 via a typical (e.g., GSM) mobile network signalling link 217. Responsive to the Connection Request message from the SS7 GW, the MSC 218 sends a Connection Confirm message on an SCCP frame via link 217. Responsive to the received Connection Confirm message, the SS7 GW 207 completes the connection sequence by transmitting a Connection Confirm message to the RNS 206 (via the IP network). It is important to note here that (although not explicitly shown in FIGURE 7) upon reception of the Connection

Confirm message from the MSC, the SS7 GW 207 initiates the establishment of a TCP connection towards the RNS 206.

In broader terms, for this exemplary embodiment, the IP-based BSS is compatible with a standard A-interface and a standard air interface. Internal to the IP-based BSS, an IP (protocol) is used. The SS7 GW 207 terminates the SS7 protocol, and converts to a TCP/IP (protocol). The TCP/IP is also used between the RNS 206 and the MGW 205, and between the RNS and the RBS 202. Alternatively, a Simple Control Transport Protocol (SCTP) can be used. For a payload, a UDP is used. Payload numbers are exchanged between the RBS and MGW via the RNS.

FIGURE 8 is a block diagram that illustrates how a traffic channel can be initially assigned, in accordance with the preferred embodiment of the present invention. As such, signalling connections or routing are denoted by the dashed lines shown in FIGURE 8, and payload connections or routing are denoted by the bold solid lines shown. FIGURE 9 is a sequence diagram that illustrates a (normal sequence) method which can be used to initially assign traffic channels, such as, for example, the traffic channel(s) described with respect to FIGURE 8. Referring to FIGUREs 8 and 9, in general for this embodiment, the Initial Assignment of a traffic channel functions to setup a payload connection between an MS (e.g., 222) and an MSC (e.g., 218) via an MGW (e.g., 205). In other words, the payload connection is not switched in an RNS. Instead, the RNS informs each endpoint (TCH, TRA) about the payload port (UDP/IP address) of the other side.

Specifically, following the exemplary method 400 shown in FIGURE 9, at step 402, an MSC (e.g., 218) initiates the sequence by transmitting an Assignment Request message via a signalling link (e.g., 217 and the IP network 208) to an RNS (e.g., 206). The Assignment Request message includes Channel Type information (Speech or Data Indicator, Channel rate and type, Speech Version(s) permitted), and an identifier for the selected A-interface circuit (Circuit Identity Code (CIC)). Upon receiving the Assignment Request message, the RNS allocates a logical channel (e.g., TCH/F for this embodiment). A connection is then setup towards an MGW (e.g., 205).

For example, at step 404, the RNS 206 sends a Connection Request message to the MGW 205 via the IP network 208. The Connection Request message includes a Seize Transcoder message, which further includes the channel services requested and the CIC. Notably, the Seize Transcoder message also includes the identity of the UDP port of the TCH/F resource selected. Responsive to receiving the Seize Transcoder message, the MGW 205 allocates a TRA resource and connects the PCM coded side of the connection to the A-interface circuit. Also, the MGW selects a free UDP port from the pool, and connects the mobile network (e.g., GSM) coded side to the selected UDP port. At step 406, the MGW sends a Connection Confirm message to the RNS 206 via the IP network 208. The Connection Confirm message includes a Seize Transcoder Acknowledgment message, which further includes the identity of the UDP port selected for the TRA.

Responsive to receiving the Connection Confirm message from the MGW, at step 408, the RNS 206 sends a Channel Activation message to the RBS 202 for the selected channel. The Channel Activation message also includes the identity of the TRA payload port. Responsive to the received Channel Activation message, at step 410, the RBS 202 sends a Channel Activation Acknowledgment message to the RNS 206 via the IP network. At step 412, the RNS then sends an Assignment Command message to the MS 222 via the IP network and radio air interface. Upon receiving the Assignment Command message, the MS stops transmitting on the old channel (SDCCH) and switches to the new channel (TCH).

For this embodiment, at the onset of Channel Activation, the BTS (in 202) starts transmitting and receiving. When the first received speech or data frame has been channel decoded by the BTS, the TRA's control bits are appended to this frame. These control bits can be used, for example, for synchronization and setting of modes in the TRA. The complete frame (including the control header) is sent to the MGW in a UDP packet via link 209. Upon receiving this frame, the TRA adjusts its timing, sets the appropriate mode, and begins transcoding. When the TRA has coded a set of speech samples, the TRA appends a header with status bits to the coded sample frame, and the entire frame is then sent to the BTS (in 202) in a UDP packet via link 209. Thereafter, UDP packets form the traffic stream on the uplink and downlink.

After the channel has been changed, at step 414, the MS initiates the establishment of a Link by use of an LAPDm SABM frame transmitted on the uplink.

In response to receiving the SABM frame, at step 416, the RBS 202 sends an Establish Indication message to the RNS 206 via the IP network, and at step 418, sends a UA message to the MS via the air interface. As such, when the MS receives the SABM frame, the link is established. When the link is thus established, at step 420, the MS sends an Assignment Complete message to the RNS (via the air interface and IP network). Upon receiving the Assignment Complete message, at step 422, the RNS sends an RF Channel Release message to the RBS 202, which commands the RBS to release the old channel. Upon receiving the RF Channel Release message, at step 424, the RBS sends an acknowledgment message to the RNS via the IP network. At step 426, the RNS then sends an Assignment Complete message to the MSC 218 (via the IP network and link 217).

FIGURE 10 is a block diagram that illustrates how an inter-cell handover can be performed, in accordance with the preferred embodiment of the present invention. As such, signalling connections or routing before and after a handover are denoted by the dashed lines shown in FIGURE 10, and payload connections or routing before and after a handover are denoted by the bold solid lines shown. FIGURE 11 is a sequence diagram that illustrates a (normal sequence) method that can be used for performing inter-cell handovers, such as, for example, the handover(s) described with respect to FIGURE 10. Referring to FIGUREs 10 and 11, in general for this embodiment, an inter-cell handover handles the movement of signalling and payload connections between different BTSs. Essentially, as described below with respect to FIGUREs 10 and 11, the payload connection is not switched in the RNS. In other words, the payload is anchored at the TRA, and the routing from the old BTS to the new BTS is changed. It is important to note that although one type of handover is described herein for this exemplary embodiment, the handover method described can be applied with slight modification to any type of handover. In any event, the handover described herein for this embodiment is an asynchronous handover between cells (inter-cell) but under the same RNS (intra-RNS). The handover switching method described herein is referred to as "Quality Based Switching at Handover" and is described in a Swedish Patent Application Number 9603560-5. On the downlink, speech is distributed to both BTSs during the handover procedure. On the uplink, the TRA involved "listens" for the payload from both BTSs, and switches from the old BTS to the new BTS upon receipt of the first correctly decoded speech frame from the new BTS.

Specifically, following the exemplary method 500 shown in FIGURE 11, a handover is initiated by the Location function in the serving cell. A new channel is then allocated in the target cell. For example, at step 502, an RNS (e.g., 206) initiates the sequence by sending (via the existing connection) a Seize Additional Transcoder Port message to an MGW (e.g., 205). This message includes the identity of the new UDP port for the target BTS (e.g., in 202b). In response, the MGW 205 allocates a new payload port, and connects this second leg to the already seized TRA device. This TRA device can now receive and transmit payloads on both legs (e.g., via 209a and 209b). At step 504, the MGW sends a Seize Additional Transcoder Port Acknowledgment message to the RNS 206 via the IP network 208. This acknowledgment message includes the identity of the new TRA payload port.

Upon receiving the acknowledgment message from step 504, at step 506, the RNS sends a Channel Activation message for the selected channel to the new BTS (e.g., via 203b). The Channel Activation message includes the identity of the new TRA payload port. At step 508, the new BTS responds to the RNS with a Channel Activation Acknowledgment message (e.g., via 203b). At steps 510 and 512, the RNS 206 then sends a Handover Command message to the MS 222 via the old BTS (e.g., via 203a to the BTS in 202a). Upon receiving the Handover Command message from the RNS, the MS 222 stops transmitting on the old channel, and switches over to the new channel.

For this embodiment, at step 514, the MS transmits Handover Access Requests (e.g., in short Access Bursts) in every (TDMA) frame until the MS receives a Physical Information message (described below). When a Handover Access Request is received by the new BTS (in 202b), at step 516, the new BTS sends a Handover Detection message to the RNS (e.g., via 203b). As discussed above, at step 518, the new BTS (e.g., in 202b) also sends a Physical Information message to the MS 222 via the air interface. This Physical Information message includes a TA value, which is used by the MS to adjust its timing and then transmit Normal Bursts (instead of the Access Bursts).

At step 520, the MS 222 then initiates the establishment of a Link by using the LAPDm SABM frame on the uplink. Upon receiving the SABM frame, at step 522, the new BTS sends (e.g., via 203b) an Establish Indication message to the RNS 206. At step 524, also in response to receiving the SABM frame, the new BTS sends a UA message to the MS on the downlink.

When the LAPDm link (e.g., 209b) is established, at step 526, the MS sends a Handover Complete message to the RNS (e.g., via the air interface and 203b). When the RNS receives the Handover Complete message, at step 528, the RNS sends a Release Old Transcoder Port message to the MGW 205 (via the IP network). In response, the MGW stops transmitting on the old payload leg (209a) and releases this leg. At step 530, the handover procedure is completed by the MGW sending a Release Old Transcoder Port Acknowledgment message to the RNS.

At step 532, the handover is finalized by the RNS sending a Handover Performed message to the MSC 218 (e.g., via the IP network and 217). This message includes the identity of the new cell. The channel in the old BTS is then released, by the RNS sending an RF Channel Release message to the old BTS (step 534), which is acknowledged with an Acknowledgment message in return (step 536).

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A base station system, comprising:

a first node connected to an Internet Protocol network, said first node operable as a host for terminating an Internet Protocol and for routing a payload;

a second node connected to said Internet Protocol network, said second node operable to convert a first protocol to said Internet Protocol; and

a third node connected to said Internet Protocol network, said third node operable to control a plurality of radio cells.

2. The base station system of Claim 1, wherein said first node comprises a radio base station.

3. The base station system of Claim 1, wherein said second node comprises a gateway.

4. The base station system of Claim 1, wherein said second node comprises an SS7 gateway and a media gateway.

5. The base station system of Claim 1, wherein said third node comprises a radio network server.

6. The base station system of Claim 1, wherein said third node is further operable to setup and release a connection between a mobile station and a mobile switching center.

7. The base station system of Claim 1, wherein said second node includes a media gateway, said media gateway operable to transcode circuit-switched speech and rate adapt circuit-switched data.

8. The base station system of Claim 1, wherein said second node includes an SS7 gateway.

9. The base station system of Claim 1, wherein said first node and said third node are coupled by a signal link, said signal link operable to convey traffic signalling information.

10. A method for establishing a signalling connection in an IP-based base station system, comprising the steps of:

a mobile station requesting a channel for said signalling connection;

a first node in said IP-based base station system allocating said channel for said signalling connection;

conveying a channel assignment message to said mobile station, said channel assignment message identifying said allocated channel;

said mobile station connecting said identified channel and establishing a link for said signalling connection;

said first node conveying a connection request to a second node in said IP-based base station system; and

said second node establishing an IP-based connection with said first node and said link established by said mobile station.

11. The method of Claim 10, further comprising the steps of:

conveying a channel required message; and

responsive to receiving said channel required message, conveying a channel activation message.

12. The method of Claim 10, wherein said first node comprises a radio network server.

13. The method of Claim 10, wherein said second node comprises an SS7 gateway.

14. The method of Claim 10, wherein said IP-based connection comprises a TCP connection.

15. The method of Claim 10, wherein said IP-based connection comprises a TCP connection or an SCTP connection.

16. The method of Claim 10, wherein said IP-based connection comprises a TCP/IP connection, and a payload is transported using a UDP protocol.

17. A method for assigning a traffic channel in an IP-based base station system, comprising the steps of:

a first node in said IP-based base station system allocating a channel;

said first node establishing a connection to a second node in said IP-based base station system;

said second node coupling a transcoder or rate adapter unit to a circuit-based traffic connection and an IP-based traffic connection;

said first node directing said mobile station to assign said allocated channel; and

said mobile station assigning said allocated channel for conveying traffic and establishing a link on said IP-based traffic connection to said transcoder or rate adapter unit.

18. The method of Claim 17, further comprising the steps of:

conveying a channel activation message; and

responsive to receiving said channel activation message, conveying a channel activation acknowledgment message.

19. The method of Claim 17, wherein said first node comprises a radio network server.

20. The method of Claim 17, wherein said second node comprises a media gateway.

21. A method for performing an inter-cell handover in an IP-based base station system, comprising the steps of:

a first node in said IP-based base station system allocating a payload port for said handover, and connecting said port to a transcoder or rate adapter unit;

conveying a channel activation request to a second node in said IP-based base station system;

responsive to said channel activation request, said second node activating a channel for said handover;

a third node in said IP-based base station system conveying a handover command to a mobile station;

responsive to said handover command, said mobile station switching to said activated channel; and

said mobile station establishing a link to said payload port.

22. The method of Claim 21, wherein said first node comprises a media gateway.

23. The method of Claim 21, wherein said second node comprises a radio base station.

24. The method of Claim 21, wherein said third node comprises a radio network server.

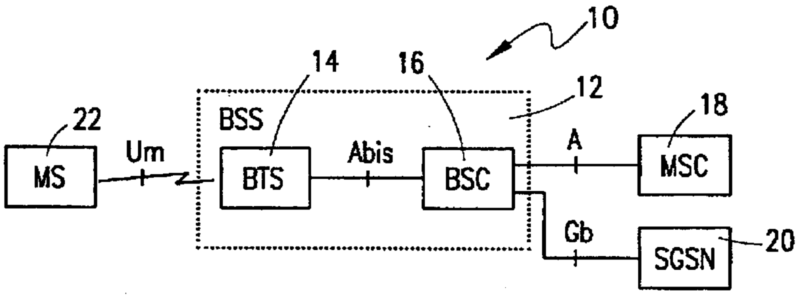

FIG. 1

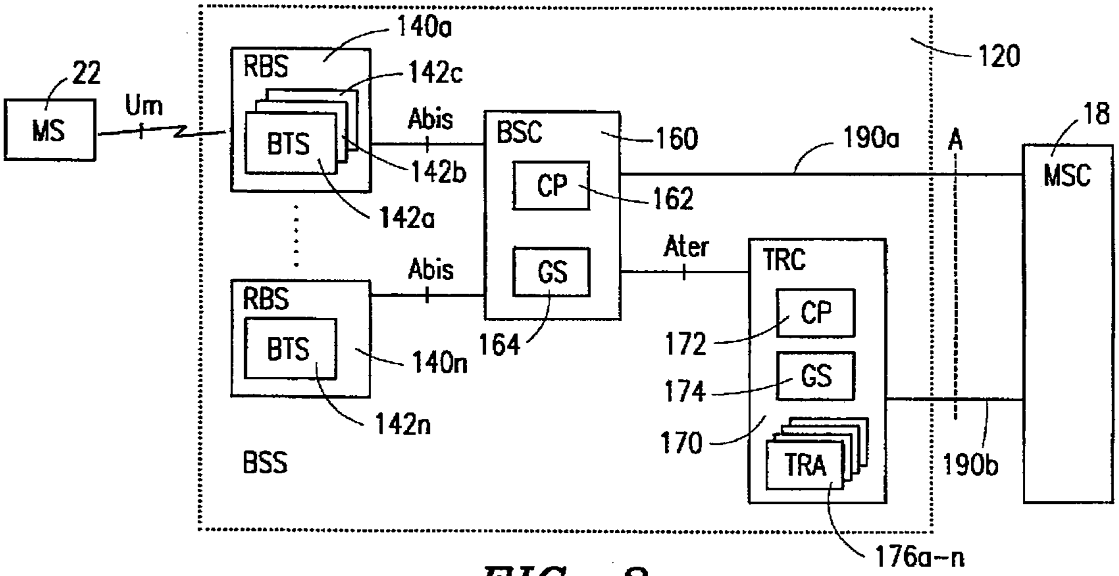

FIG. 2

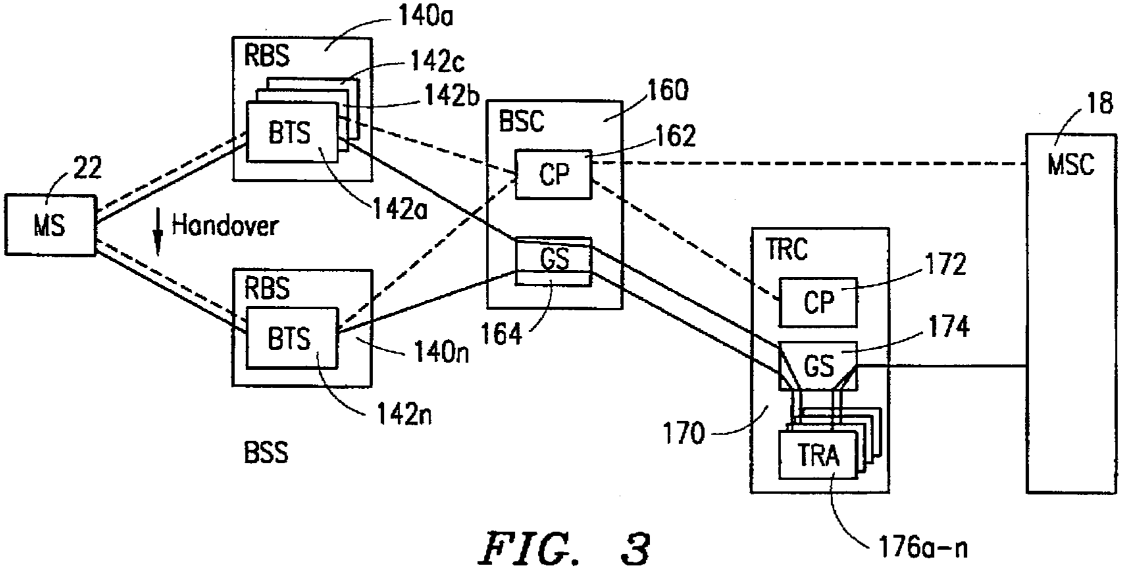

FIG. 3

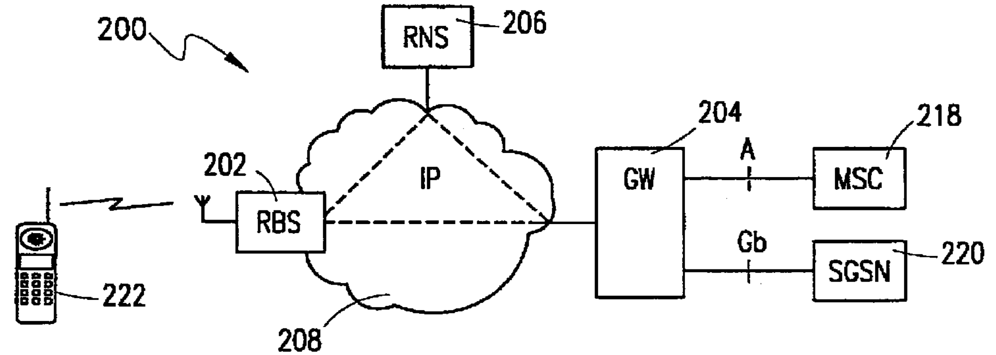

FIG. 4

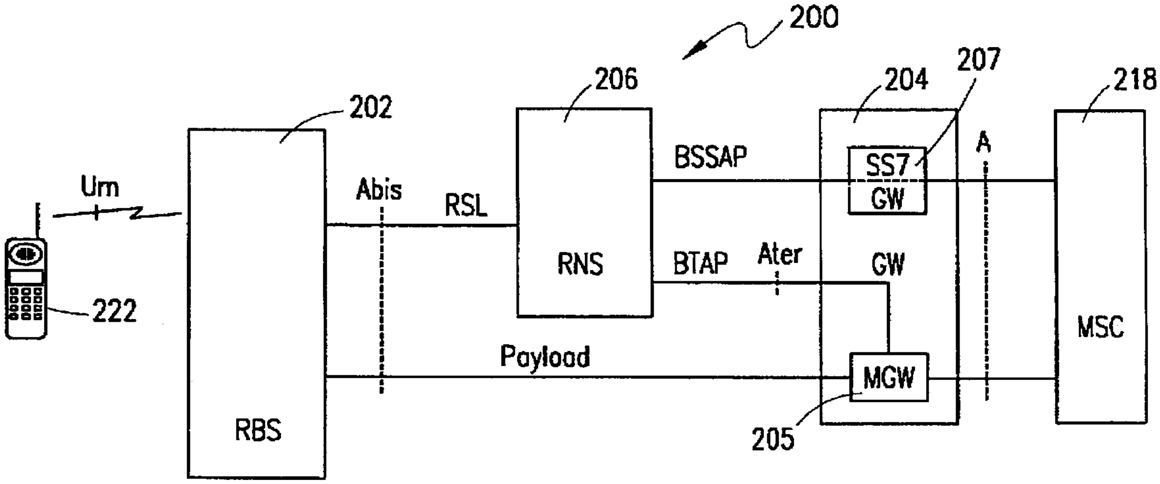

FIG. 5

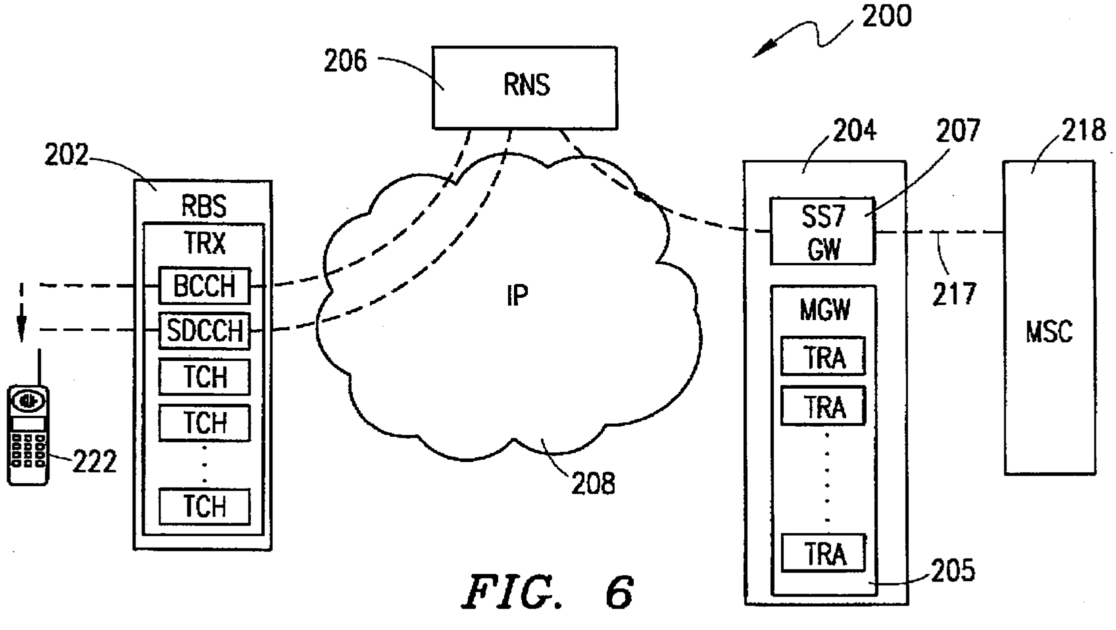

FIG. 6

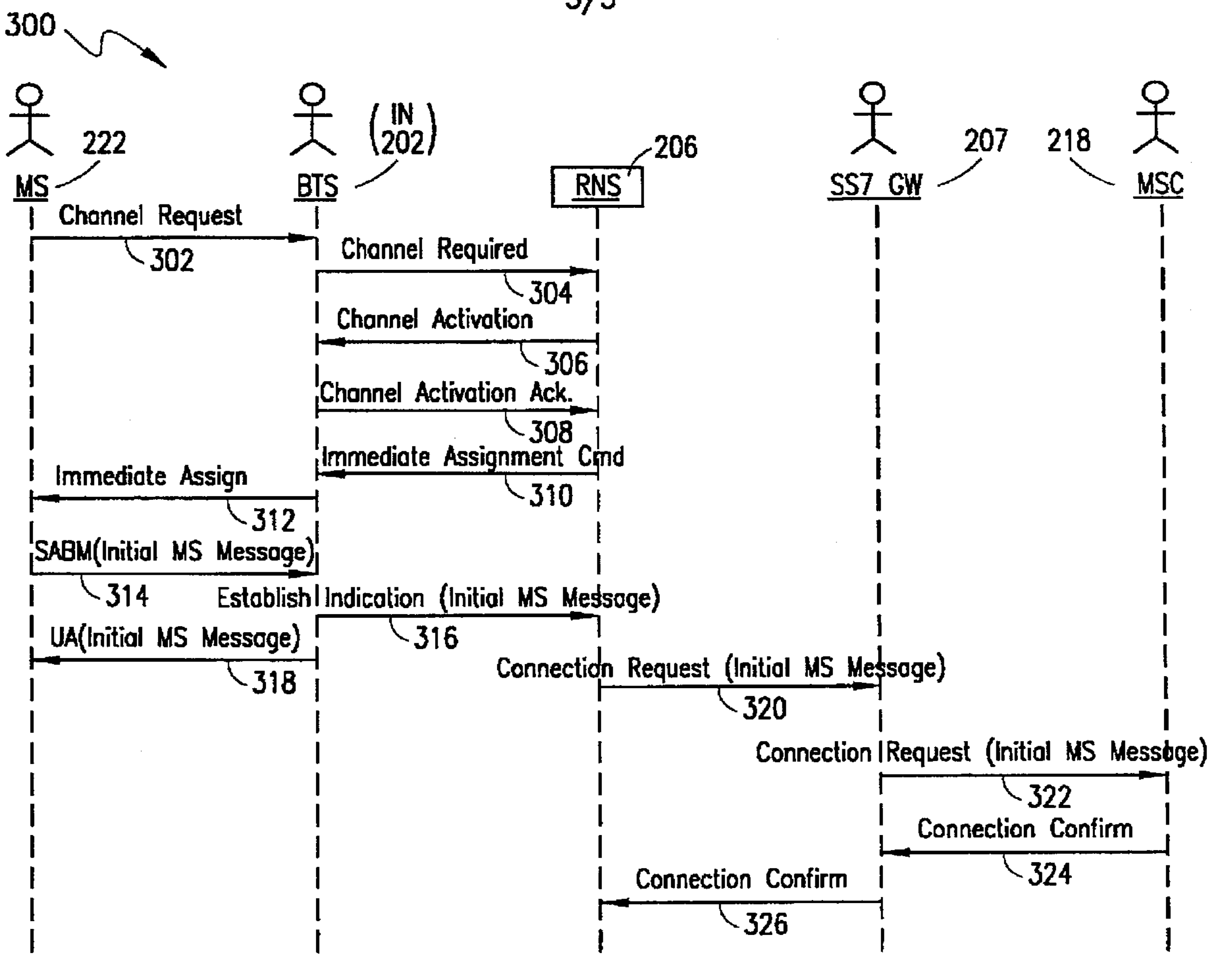
300
MS
222
BTS
(IN 202)
RNS
206
SS7 GW
207
218
MSC
Channel Request
302
Channel Required
304
Channel Activation
306
Channel Activation Ack.
308
Immediate Assignment Cmd
310
Immediate Assign
312
SABM(Initial MS Message)
314
Establish Indication (Initial MS Message)
316
UA(Initial MS Message)
318
Connection Request (Initial MS Message)
320
Connection Request (Initial MS Message)
322
Connection Confirm
324
Connection Confirm
326

FIG. 7

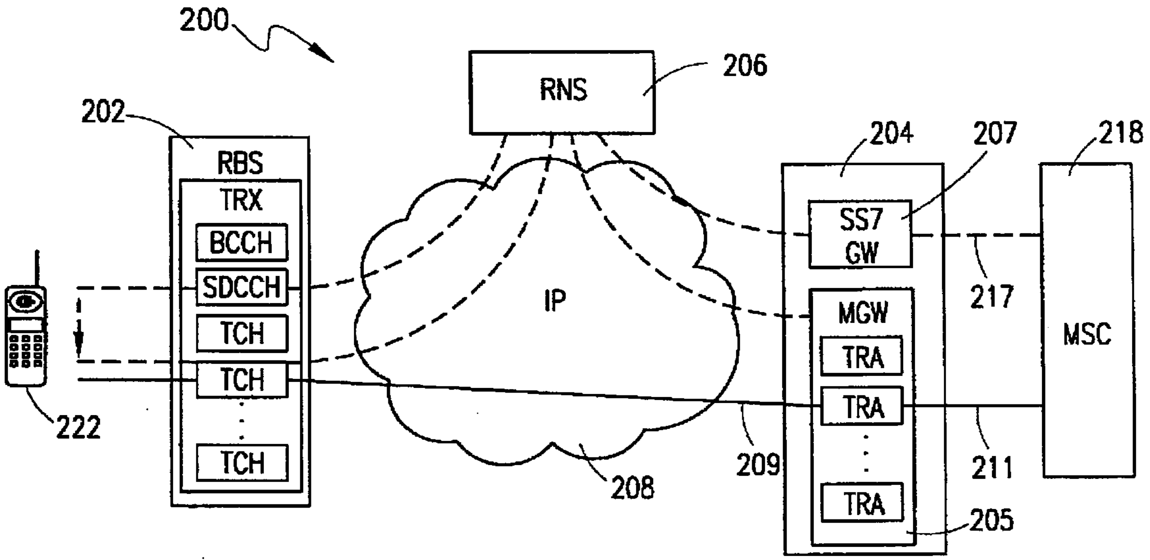
200
RNS
206
202
RBS
TRX
BCCH
SDCCH
TCH
TCH
TCH
IP
204
207
218
SS7 GW
217
MGW
TRA
TRA
TRA
MSC
209
211
222
208
205

FIG. 8

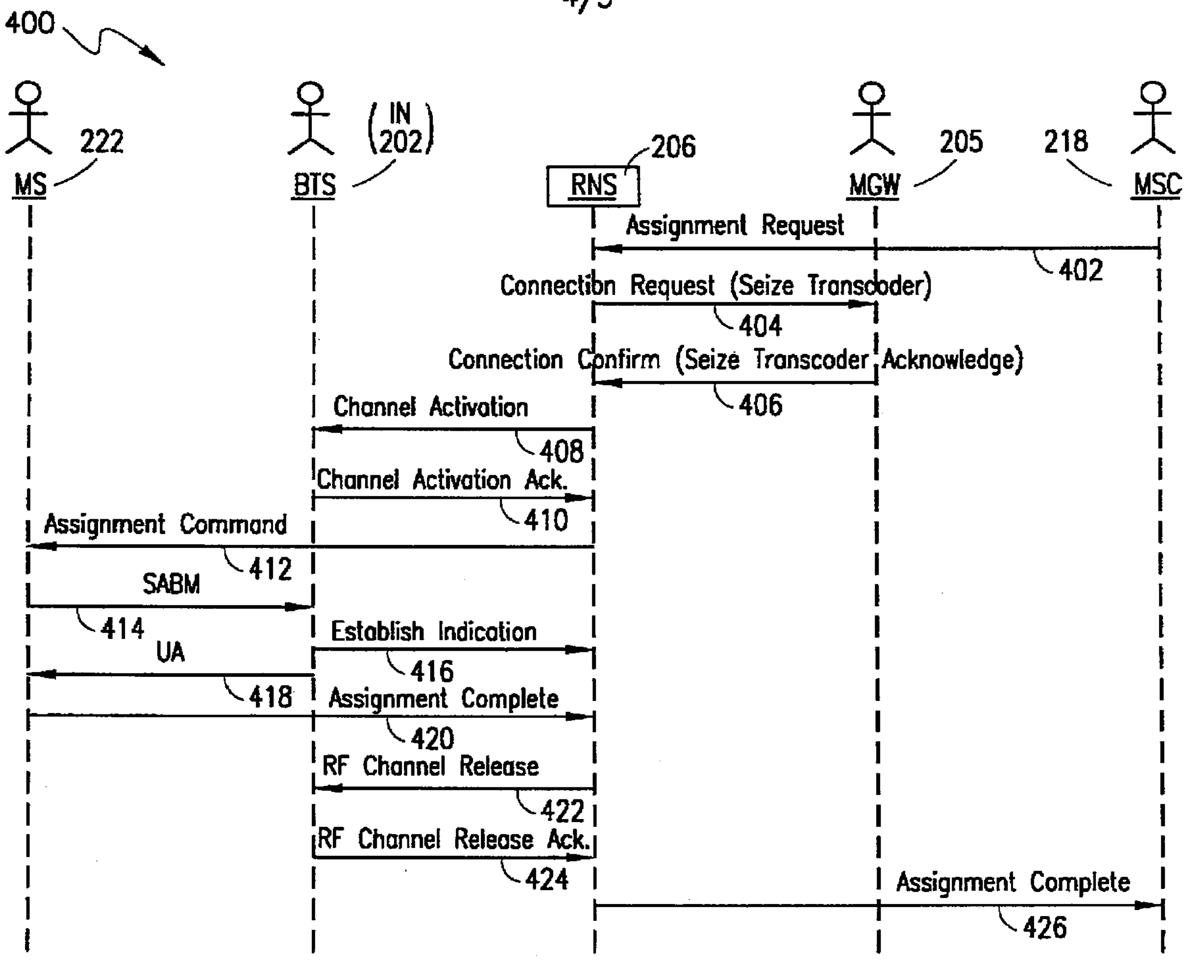
400
222
MS
IN 202
BTS
206
RNS
205
MGW
218
MSC
Assignment Request
402
Connection Request (Seize Transcoder)
404
Connection Confirm (Seize Transcoder Acknowledge)
406
Channel Activation
408
Channel Activation Ack.
410
Assignment Command
412
SABM
414
Establish Indication
416
UA
418
Assignment Complete
420
RF Channel Release
422
RF Channel Release Ack.
424
Assignment Complete
426

FIG. 9

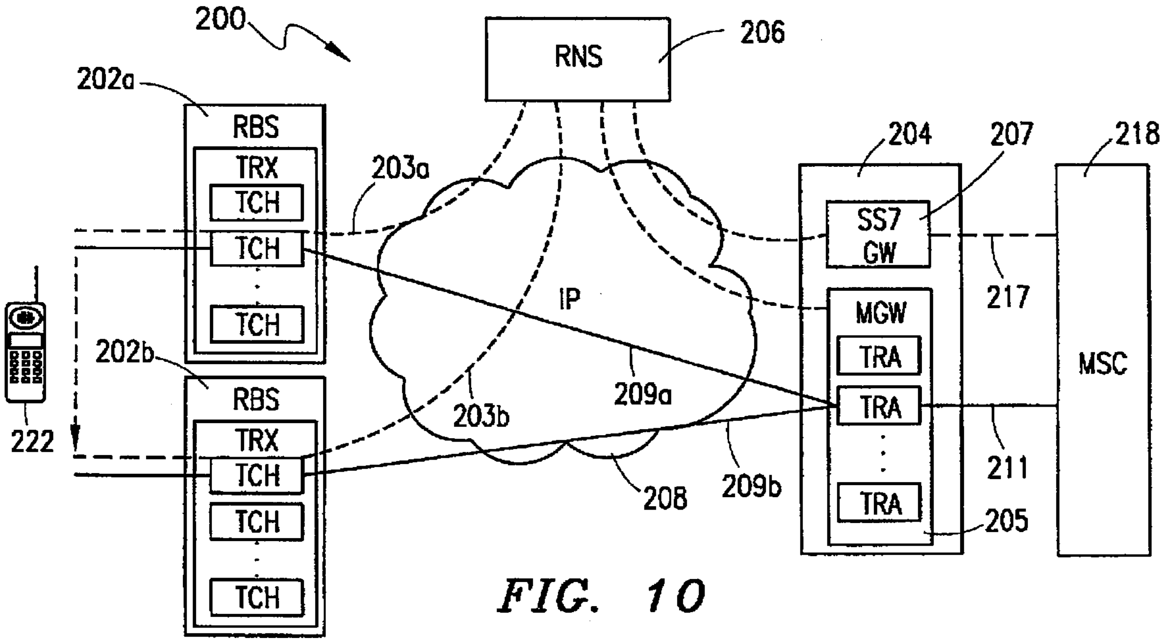
200
206
RNS
202a
RBS
TRX
TCH
TCH
TCH
203a
204
207
218
SS7 GW
217
IP
MGW
TRA
TRA
TRA
MSC
202b
RBS
TRX
TCH
TCH
TCH
222
203b
209a
208
209b
211
205

FIG. 10

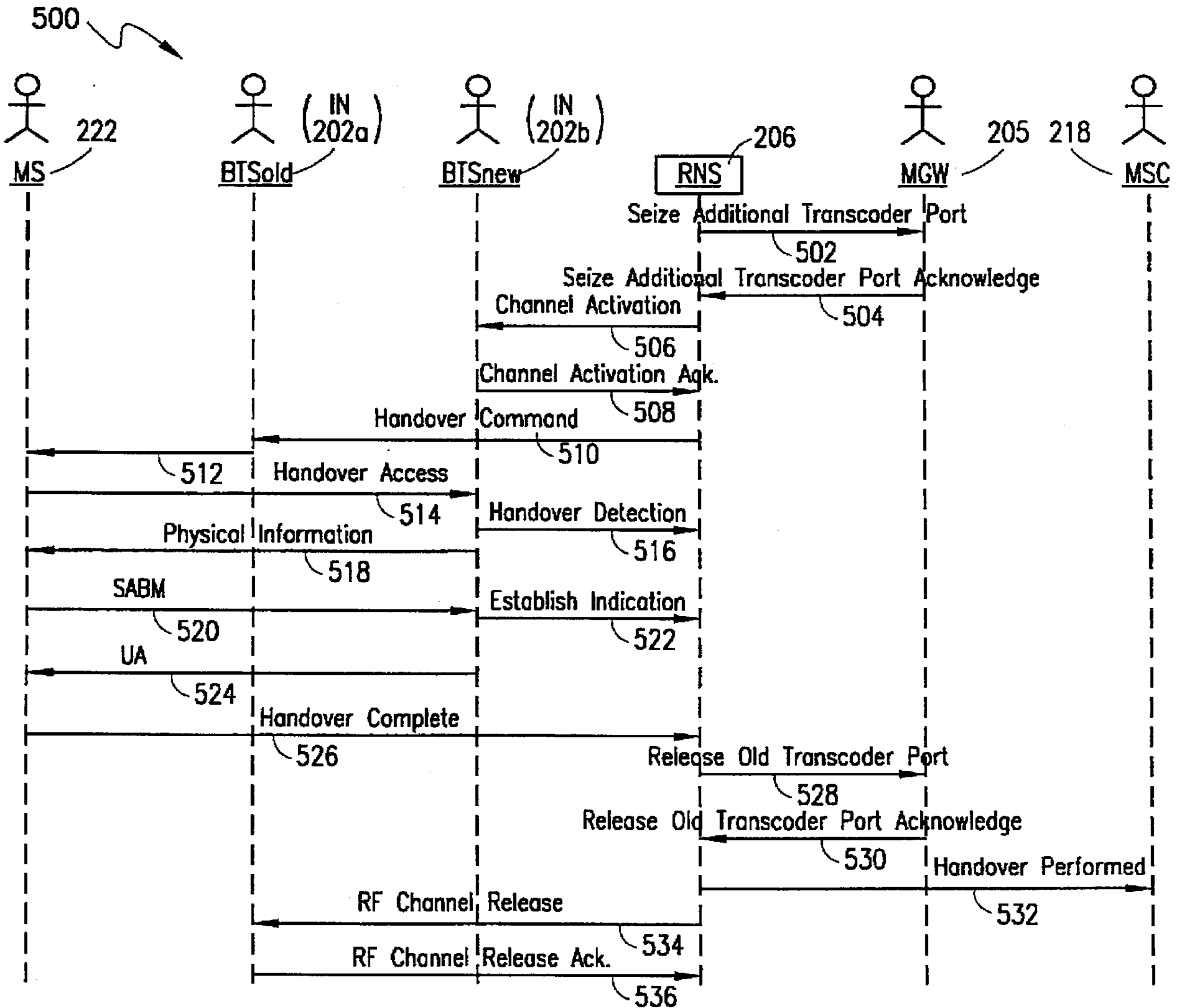
500
MS
222
BTSold
IN
202a
BTSnew
IN
202b
RNS
206
MGW
205
218
MSC
Seize Additional Transcoder Port
502
Seize Additional Transcoder Port Acknowledge
504
Channel Activation
506
Channel Activation Ack.
508
Handover Command
510
512
Handover Access
514
Handover Detection
516
Physical Information
518
SABM
520
Establish Indication
522
UA
524
Handover Complete
526
Release Old Transcoder Port
528
Release Old Transcoder Port Acknowledge
530
Handover Performed
532
RF Channel Release
534
RF Channel Release Ack.
536

FIG. 11